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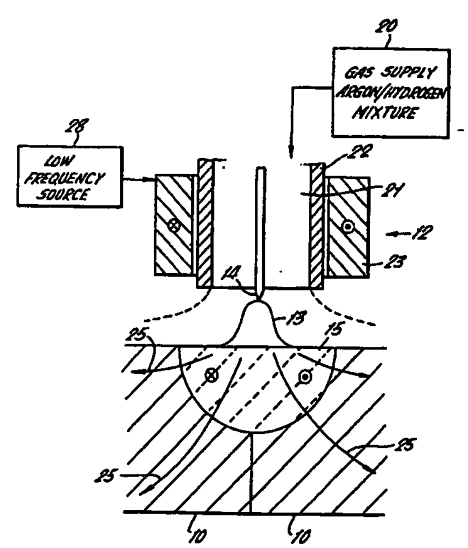
(54) Magnetic stirring in TIG welding

(57) In TIG welding a magnetic field is provided to stir the weld pool. Preferably the field is produced by a solenoid 23 around the welding head 12 (or a magnet), this field, in conjunction with the arc current flowing through the molten metal in the weld pool 15, to stir the metal in the weld pool and hence to give a more uniform heat distribution leading to greater consistency in the welding process. A H_2/Ar gas mixture is used.



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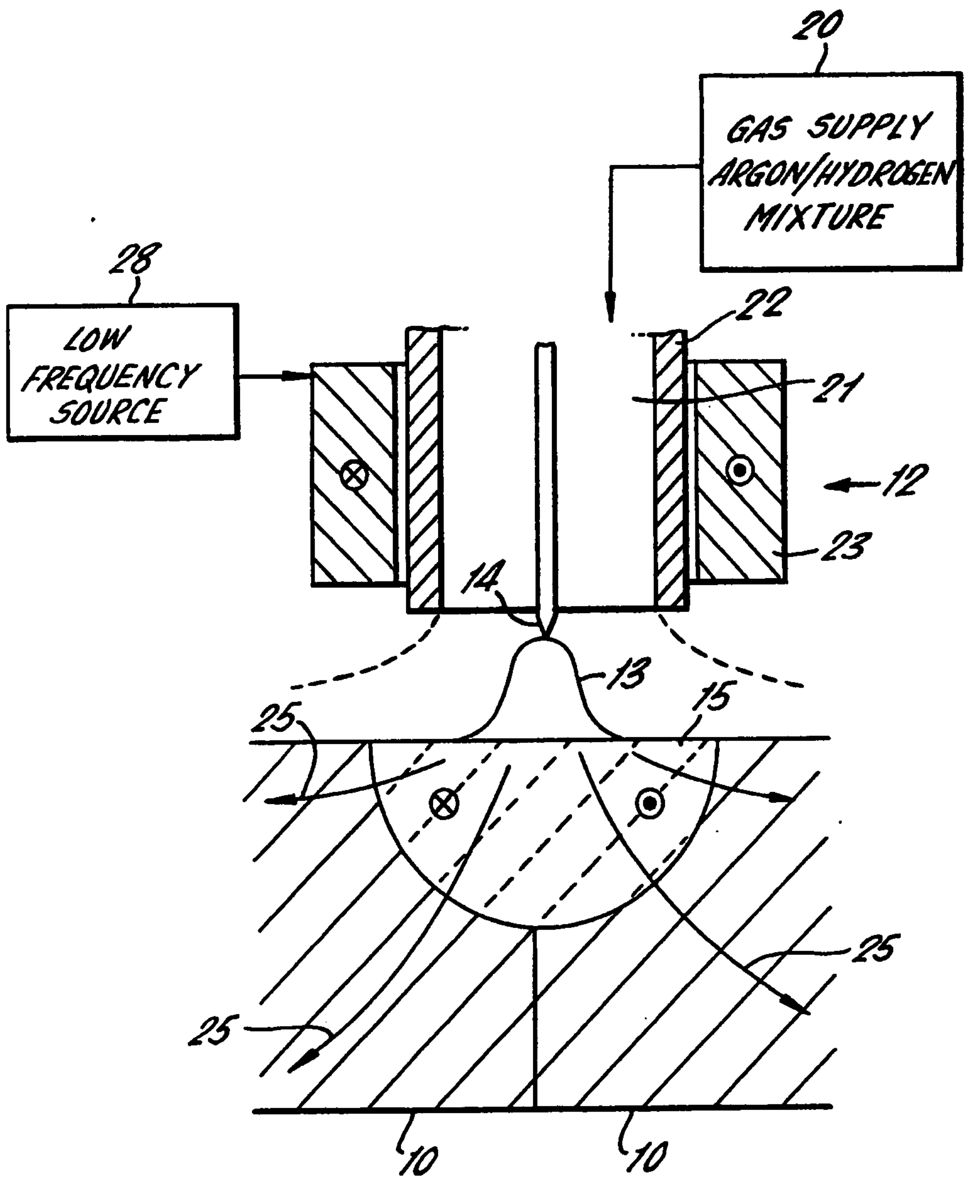
20
GAS SUPPLY
ARGON/HYDROGEN
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SPECIFICATION

Improvements in or relating to electric arc welding

This invention relates to electric arc welding employing a TIG (Tungsten inert gas) welding process.

In a TIG welding process, a weld pool is created by an arc which is struck between a tungsten electrode and the workpieces which are to be joined together. The weld pool is normally constituted of approximately equal amounts of material melted from the two workpieces. This weld pool has to be deep enough to penetrate the full thickness of the plates. In order to obtain satisfactory welding, there should be consistent penetration to the full depth of the weld and adequate mixing of the metal of the two workpieces, particularly in the case of joining dissimilar materials. If too little material is melted, the joint is weak whereas if too much material is melted, the joint is uneven in shape.

The present invention is concerned with improving the consistency of welding using a TIG (Tungsten inert gas) welding process. The inert gas is usually argon although helium may be employed. It has been known for some time that the inclusion of hydrogen, typically up to about 10% by volume of the argon, in the gas shield around the arc of a TIG weld leads to increased penetration properties of the weld pool. The addition of hydrogen however does not necessarily reduce the variations in the process although under some conditions, especially in "bead on plate" welds, a reduction of variance can sometimes be demonstrated. The inconsistencies however in reduction of variance make the application of welding processes involving the addition of hydrogen to the argon gas in the shield only of limited advantage if the welds are to be of the best technological standards.

According to this invention, in a method of welding two workpieces together using a TIG process in which hydrogen is included with the argon or helium in a gas shield around the arc, the weld pool in the workpiece produced by the arc is stirred during the welding operation by an applied magnetic field. The amount of hydrogen to be added would be in accordance with the permissible limits of the material to be welded. For welding of steel using argon as the inert gas, the amount of hydrogen typically would be up to about 10% by volume of the argon.

By this process, the advantages of increased penetration due to the addition of hydrogen in the inert gas shield can be obtained. The magnetic stirring of the metal in the weld pool, which is effected by the action on the molten metal of the magnetic field in conjunction with the arc current which flows through the molten metal, results in the heat being much more uniformly distributed than would be the case without such magnetic stirring. The fluid motion transfers heat input from the region immediately underneath the arc into and to one side of the weld pool. The magnetic field is preferably coaxial with the arc. This causes the arc and the pool to rotate about this axis. The field assists in stabilising the position of the arc on the molten metal but the rotation, by stirring the metal in the pool, tends to give rise to asymmetric heat flow in the pool with respect to the welding centre line and hence the weld pool may be skewed with respect to the line of the weld. Depending on the orientation of the workpiece, this may be acceptable, for example in a horizontal/vertical weld. Particularly for downhand welding, it may be desired to restore symmetry and this may be achieved by reversing the direction of stirring periodically as the weld progresses. If the period of reversal is long, the asymmetry would be detectable as a zig-zag pattern on the front and back faces of the weld. This zig-zag pattern however may be avoided by utilising a shorter period of stirring in each direction. The period however should be sufficiently long to give significant motion to the metal in the weld pool. It will be appreciated that the forces acting on the metal will depend inter alia on the magnitude of the welding current and on the magnitude of the applied magnetic field. It is readily possible however to choose a suitable frequency giving a symmetrical weld with no significant weld pattern produced by the magnetic field reversals.

If the arc current is unidirectional, reversal of the direction of stirring can be achieved by reversing the magnetic field, e.g. by reversing the current through a solenoid generating the field. In some cases, e.g. in welding aluminium, an alternating current in the arc is preferred. In this case, a synchronised alternating supply to the solenoid may be employed; reversal of the phase of the solenoid supply with respect to the welding current will reverse the direction of stirring.

The application of magnetic stirring on its own tends to increase the ratio of the width to the depth of the weld pool due to the heat being spread laterally and thereby degrades the penetration properties of the welding process. The provision, in the method of the present invention, of hydrogen in the shield gas gives however increased penetration thereby avoiding this disadvantage of the use of magnetic stirring. The fluid motion using magnetic stirring transfers the heat input underneath the arc towards one side of the weld pool; the rotary stirring action ensures however that this heat is uniformly distributed. There is no perturbation however of the position of the weld pool if the magnetic field is periodically reversed.

The combination of the magnetic stirring with the hydrogen injection into the shielding gas gives a more stable control over the heat transfer so leading to reproducible fusion zone dimensions. This is of particular advantage in the automatic control of welding operations. It may be used for example in conjunction with techniques for determining and controlling the position and size of a weld pool by front face or by rear face viewing making use of sensing means providing signals dependent on the dimensions of the weld pool or dependent on the radiation from the weld pool and workpiece.

The correlation between the arc power input and the weld pool dimension is improved by the technique of the present invention.

The invention furthermore includes within its scope welding apparatus comprising a TIG torch having means for feeding a mixture of argon or

helium with hydrogen as a shielding gas around the arc in combination with means arranged on or in the torch for producing a magnetic field coaxial with the arc.

The means for producing a magnetic field may comprise a permanent magnet, e.g. an annular magnet around the torch. Preferably however the means for producing the magnetic field comprises a solenoid; as described above this may be fed with an alternating or periodically reversed current to reverse the direction of stirring as described above.

The following is a description of one embodiment of the invention, reference being made to the accompanying drawing which is a diagrammatic section through part of a TIG welding apparatus and associated workpiece.

Referring to the drawing, there is shown a workpiece comprising two abutting elements 10 to be welded together along a line extending normally to the plane of the section. The weld is effected by means of TIG torch, part of which is shown diagrammatically at 12 and which produces a welding arc indicated at 13. This arc extends from a tungsten electrode 14 to a weld pool 15 which is formed by melting of the metal of the two parts of the workpiece. Although not illustrated in the drawing, automatic control of the welding operation may be effected by sensing the position and size of the weld pool, by front face or rear face viewing, the sensor providing an output signal dependent on the dimensions of the weld pool or radiation from the workpiece. The output of such a sensor or sensors may be used to control the power fed into the arc and/or the rate of relative movement between the welding torch and the workpiece. A mixture of argon with up to 10% hydrogen is fed, from a source indicated diagrammatically at 20, into the region 21 around the electrode within a cylindrical ceramic shield 22 and thence into the region around the arc 13 to constitute a gas shield. A solenoid 23 is provided around the head of the torch outside the shield 22 to produce a magnetic field which is coaxial with the line of the electrode and of the arc. This field thus produces rotation of the arc without altering its position on the workpiece. The weld pool produced by the arc is indicated diagrammatically at 15; the arc current flows through this pool of molten metal as indicated diagrammatically by the lines 25. The interaction of the magnetic field with the current flow in the molten metal causes stirring of the metal in the weld pool about the axis of the arc.

The resultant fluid motion transfers heat input from the region immediately underneath the arc into and towards one side of the weld pool. The stirring of the metal in the weld pool however causes the heat being more uniformly distributed. This electromagnetic stirring tends to increase the width of the weld pool and reduce penetration but the injection of hydrogen into the shielding gas improves the penetration and, as previously explained, by this technique of using electromagnetic stirring in conjunction with hydrogen injection into the shielding gas, one can obtain improved and more consistent welding, by the better heat distribution, without degradation of the penetration into the workpiece.

As previously explained, the electromagnetic stirring may be periodically reversed, if the arc current is unidirectional, by reversing the current to the solenoid or, as shown in the drawing, by feeding the solenoid from an alternating current source 28. This typically is a low frequency source, having a frequency of a few Hz. The frequency is not critical and satisfactory results may be obtained over a wide working range of frequencies. The stirring occurs by reason of the interaction of the welding current, flowing in the molten metal and the magnetic field produced by the solenoid. The welding current may be a pulsed current or a direct current. The current fed to the solenoid may be an alternating current or a switched, e.g. pulsed, current or a direct current. The arrangement employed would be chosen in accordance with the requirements of the welding operation, in particular the configuration of the weld.

If the arc current is alternating, as is used in welding aluminium for example, the solenoid is energised by an alternating supply synchronised with the arc current to obtain a unidirectional stirring effect. Reversal of the direction of stirring is then obtained by reversing the phase of the solenoid supply with respect to the arc current.

CLAIMS

1. A method of welding two workpieces together using a TIG process in which hydrogen is included with the argon or helium in a gas shield around the arc and wherein the weld pool in the workpiece, produced by the arc, is stirred during the welding operation by an applied magnetic field.

2. A method as claimed in claim 1 wherein the applied magnetic field is coaxial with the arc.

3. A method as claimed in either of the preceding claims wherein the applied magnetic field is periodically reversed in direction.

4. A method as claimed in either claim 1 or claim 2 wherein the applied magnetic field is unidirectional and wherein a pulsed unidirectional welding current is employed.

5. Welding apparatus comprising a TIG torch having means for feeding a mixture of argon or helium with hydrogen as a shielding gas around the arc, in combination with means arranged on or in the torch for producing a magnetic field coaxial with the arc.

6. Welding apparatus as claimed in claim 5 wherein the means for producing a magnetic field comprises a permanent magnet.

7. Welding apparatus as claimed in claim 5 wherein the means for producing a magnetic field comprises a solenoid.

8. A method of welding two workpieces together substantially as hereinbefore described with reference to the accompanying drawing.

9. A welded workpiece produced by the method of any of claims 1 to 4 or claim 8.

10. Welding apparatus for carrying out the method of claim 1 and substantially as hereinbefore described with reference to the accompanying drawing.

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